# Index of Topics

The following seven charts are an index of the topics in all 28 conceptual flow diagrams of the Scope and Sequence. There is one chart for each principle. For each chart, the major branches of topics on the conceptual flow diagrams for that principle run horizontally across the top; the grade bands run vertically along the left column.

| 1 | The Earth has one big ocean with many features. | | | |
|---|---|---|---|---|
| | **Properties of Ocean Water** | **Geographic and Geologic Features** | **Ocean Circulation** | **Sea Level** |
| K-2nd | • The ocean is salty | • Ocean basins<br>• Ocean floor features<br>• Only one ocean | • Tides<br>• Transportation of living things<br>• Watersheds<br>• Wind-driven currents | |
| 3rd-5th | • Density-driven currents<br>• Salinity<br>• Temperature<br>• Where fresh water is<br>• Where salt water is | • Highest mountain on Earth<br>• Lowest point on Earth<br>• Ocean basins<br>• Ocean floor features | • Currents<br>• Only one ocean<br>• Tides<br>• Transportation of living things<br>• Water cycle<br>• Watersheds<br>• Waves | |
| 6th-8th | • Density<br>• Density-driven currents<br>• Freezing point<br>• How ocean became salty<br>• pH<br>• Salinity<br>• Temperature | • Change over geologic time<br>• Convection<br>• Generation of Earth's crust<br>• Motion of lithospheric plates<br>• Ocean basins<br>• Ocean floor features<br>• Supercontinent | • Density-driven currents<br>• Only one ocean<br>• Sea level rising<br>• Tides<br>• Transportation of living things<br>• Watersheds<br>• Wind-driven currents<br>• Upwelling | |
| 9th-12th | • Density<br>• Effect on life processes<br>• pH<br>• Salinity<br>• Temperature | • Generation of Earth's crust<br>• Motion of lithospheric plates<br>• Ocean basins<br>• Ocean floor features<br>• Tectonic activities | • Coriolis effect<br>• Currents<br>• Density-driven currents<br>• Eckman forces<br>• Effect on climate<br>• Gyres<br>• Prevailing winds<br>• Tides<br>• Transportation of living things<br>• Upwelling<br>• Water cycle<br>• Waves<br>• Wind-driven currents | • Atmospheric pressure<br>• Change over time<br>• Effect on currents<br>• Global temperature change<br>• Movement of lithospheric plates<br>• Prevailing winds<br>• Regional differences |

| 2 | The ocean and life in the ocean shape the features of the Earth. | | | |
|---|---|---|---|---|
| | Coastal Erosion | Plate Tectonics | Rock Cycle | Biogeochemical Cycle |
| K-2nd | • Deposition of Earth materials<br>• Erosion of Earth materials | | | |
| 3rd-5th | • Beach composition<br>• Currents as agents of sedimentation<br>• Erosion of biotic materials<br>• Erosion of Earth materials<br>• Formation of sand<br>• Rivers as agents of sedimentation<br>• Sedimentation<br>• Water as an agent of erosion<br>• Waves as agents of sedimentation | | • Marine fossils<br>• Marine organisms contribute to rock formation<br>• Ocean sediments<br>• Sedimentary rock composition<br>• Volcanic rock formation | |
| 6th-8th | • Biological weathering<br>• Chemical weathering<br>• Changing coastlines<br>• Changing sea level<br>• Erosion<br>• Deposition<br>• Landforms uncovered by sea level change<br>• Physical weathering | • Earthquakes<br>• Mountain formation<br>• Subduction<br>• Sea level change<br>• Tectonic activities<br>• Volcanoes<br>• Uplift | • Coral reef formation<br>• Igneous rock formation<br>• Marine organisms contribute to rock formation<br>• Metamorphic rock formation<br>• Stromatolites<br>• Sedimentary rock formation | |
| 9th-12th | | • Continental plates<br>• Erosion<br>• Geologic features from subduction<br>• Oceanic plates<br>• Residence times<br>• Subduction<br>• Tectonic activity<br>• Weathering | • Accretion<br>• Igneous processes<br>• Sedimentation<br>• Volcanism | • Carbon cycle<br>• Elements in ocean water<br>• Nitrogen cycle<br>• Phosphorus cycle<br>• Silica cycle |

| 3 | The ocean is a major influence on weather and climate. | | | |
|---|---|---|---|---|
| | Weather and Climate | Water Cycle | Global Climate Change | Consequences of Global Climate Change |
| K-2nd | | • Condensation<br>• Evaporation<br>• Precipitation<br>• Runoff<br>• Watersheds | | |

| 3 | The ocean is a major influence on weather and climate. | | | |
|---|---|---|---|---|
| | **Weather and Climate** | **Water Cycle** | **Global Climate Change** | **Consequences of Global Climate Change** |
| 3rd-5th | • Convection currents<br>• Creation of wind<br>• Energy absorption<br>• Ocean currents<br>• Temperature fluctuation<br>• Wind energy | • Condensation<br>• Energy absorption<br>• Evaporation<br>• Precipitation<br>• Runoff<br>• Where fresh water comes from | | |
| 6th-8th | • Atmospheric convection<br>• El Niño<br>• Energy absorption<br>• Heat exchange<br>• Weather and climate patterns | • Condensation<br>• Evaporation<br>• Energy absorption<br>• Ocean currents move heat<br>• Precipitation | • Atmospheric carbon dioxide<br>• Human effects<br>• Ocean absorption of $CO_2$<br>• pH<br>• Photosynthetic organisms | |
| 9th-12th | • Atmospheric convection<br>• Differential heating<br>• El Niño and La Niña<br>• Energy absorption<br>• Energy transfer<br>• Evaporation<br>• Heat capacity<br>• Ocean currents move heat<br>• Precipitation<br>• Weather and climate patterns<br>• Wind energy | | • Atmospheric warming<br>• Carbon cycle<br>• Carbon dioxide balance<br>• Greenhouse gases<br>• Greenhouse effect<br>• Human effects<br>• Ocean absorption of $CO_2$<br>• Ocean circulation pattern<br>• pH<br>• Photosynthesis | • Change in ocean circulation<br>• Change in ocean temperature<br>• Decreased solar reflection<br>• El Niño and La Niña<br>• Frequency and intensity of weather events<br>• Melting of glaciers and ice caps<br>• Ocean acidification<br>• Rising sea level |

| 4 | The ocean makes Earth habitable. | |
|---|---|---|
| | **Origins of Life** | **Oxygen Production** |
| K-2nd | • Water is necessary for life<br>• Where water is on Earth | |
| 3rd-5th | • Bacteria<br>• Fossil evidence<br>• Life started in the ocean | • Earth's atmosphere<br>• Photosynthesis |
| 6th-8th | • Chloroplast<br>• Cyanobacteria<br>• Fossil evidence<br>• Life started in the ocean<br>• Ocean sediments<br>• Theory of evolution | • Cyanobacteria<br>• Earth's atmosphere<br>• Oxygen consumption<br>• Ozone<br>• Photosynthesis<br>• Respiration and decay |

| 4 | The ocean makes Earth habitable. | |
|---|---|---|
| | **Origins of Life** | **Oxygen Production** |
| 9th-12th | • Fossil evidence<br>• Life started in the ocean<br>• Hydrothermal vents<br>• Prokaryotes and eukaryotes<br>• Theory of evolution | • Aerobic respiration<br>• Balance of oxygen and carbon dioxide<br>• Cyanobacteria<br>• Decay<br>• Dissolved oxygen<br>• Earth's atmosphere<br>• Photosynthesis<br>• Oxidation<br>• Ozone |

| 5 | The ocean supports a great diversity of life and ecosystems. | | | |
|---|---|---|---|---|
| | **Primary Productivity** | **Diversity of Ecosystems** | **Diversity of Life** | **Diversity of Life: Adaptations to Environmental Factors (9-12 only)** |
| K-2nd | | • Adaptations<br>• Habitats | • Adaptations<br>• Organism diversity<br>• Size and scale of life | |
| 3rd-5th | | • Coastal ecosystems<br>• Conditions for photosynthesis<br>• Coral reefs<br>• Deep water ecosystems<br>• Estuaries<br>• Open ocean<br>• Physical properties of the ocean<br>• Phytoplankton | • Adaptations<br>• Adaptations for living in the ocean<br>• Life cycles<br>• Metamorphosis<br>• Migration organism diversity<br>• Physical properties of the ocean<br>• Size and scale of life | |
| 6th-8th | • Abundance of life<br>• Chemosynthesis<br>• Chemosynthetic ecosystems<br>• Conditions for photosynthesis<br>• Coral reefs<br>• Coriolis effect<br>• Estuaries<br>• Food webs<br>• Kelp forests<br>• Mangroves<br>• Photosynthetic organisms<br>• Polar seas<br>• Symbiosis<br>• Upwelling | • Abiotic factors<br>• Adaptations for living in the ocean<br>• Climate change effect on environments<br>• Ecosystems<br>• Food webs<br>• Habitats<br>• Habitat zonation<br>• Human effect on environments<br>• Physical properties of the ocean | • Adaptations for living in the ocean<br>• Biomass<br>• Conditions for diversity<br>• Life cycles<br>• Life histories<br>• Migration<br>• Organism diversity<br>• Physics of sound<br>• Reproduction<br>• Size and scale of life | |

| 5 | The ocean supports a great diversity of life and ecosystems. | | | |
|---|---|---|---|---|
| | **Primary Productivity** | **Diversity of Ecosystems** | **Diversity of Life** | **Diversity of Life: Adaptations to Environmental Factors (9-12 only)** |
| 9th-12th | • Autotrophs<br>• Chlorophyll<br>• Carbon fixation<br>• Heterotrophs<br>• Microbes<br>• Nutrient cycling<br>• Nutrients in photosynthesis<br>• Organic molecules<br>• Primary production definition<br>• Upwelling | • Abiotic factors<br>• Abundance of life<br>• Adaptations to environmental conditions<br>• Chemosynthetic organisms<br>• Coral reefs<br>• Diversity of life<br>• Estuaries<br>• Food webs<br>• Habitat zonation<br>• Hydrothermal vent communities<br>• Intertidal habitats niches<br>• Kelp forests<br>• Niches<br>• Open ocean<br>• Physical properties of the ocean<br>• Productivity<br>• Upwelling | • Diversity of adaptations to environmental factors<br>• Diversity of feeding behaviors<br>• Diversity of life cycles and reproductive strategies<br>• Phyletic diversity | • Adaptations for diving<br>• Adaptations to varying light levels<br>• Bioluminescence<br>• Camouflage<br>• Coral bleaching<br>• Features of sound<br>• Light filtration<br>• Human effects on organisms<br>• Ocean acidification and its effects<br>• Osmoregulation<br>• Physical characteristics of the ocean<br>• Plankton adaptations<br>• Sound as communication |

| 5 | The ocean supports a great diversity of life and ecosystems. | | |
|---|---|---|---|
| | **Diversity of Life: Life Cycles and Reproductive Strategies (9-12 only)** | **Diversity of Life: Feeding Behaviors (9-12 only)** | **Diversity of Life: Phyletic Diversity (9-12 only)** |
| 9th-12th | • Alternation of generations<br>• Asexual reproduction<br>• Broadcast spawning<br>• Hermaphroditism<br>• Parasitism as a reproductive strategy<br>• Parental care strategies<br>• Population density effects on reproductive strategies<br>• Sexual reproduction<br>• Strategies for maximizing dispersal<br>• Strategies for maximizing fertilization<br>• Transitions between lifestyles | • Buoyancy<br>• Filter feeding<br>• Mutualisms<br>• Physical characteristics of the ocean<br>• Strategies for capturing food<br>• Strategies for exploiting patchy distribution of food<br>• Symbiosis | • Bioluminescence<br>• Biomass<br>• Chemosynthetic organisms<br>• Cyanobacteria<br>• Diatoms<br>• Dinoflagellates<br>• Eukaryotes<br>• Fish diversity<br>• Fungi<br>• Heterotrophs<br>• Invertebrate diversity<br>• Land to ocean transition<br>• Phyla found in the ocean<br>• Physical characteristics of the ocean<br>• Phytoplankton<br>• Productivity<br>• Prokaryotes<br>• Ocean to land transition<br>• Origins of life<br>• Seaweed diversity<br>• Size and scale of life<br>• Symbiosis<br>• Vertebrate evolution |

| 6 | The ocean and humans are inextricably interconnected. | | | | |
|---|---|---|---|---|---|
| | Uses of the Ocean | Where People Live | Human Impact on the Ocean and Atmosphere | The Ocean Affects Weather and Climate which Impacts People | Responsibility and Advocacy for the Ocean |
| K-2nd | • Commerce<br>• Food resources<br>• Human benefits from the ocean<br>• Recreation<br>• Source of fresh water<br>• Transportation<br>• Water cycle | • Human population distribution<br>• Weather impacts on humans | • Human impacts on changing shorelines<br>• Pollution<br>• Human efforts to protect the ocean<br>• Recycling<br>• Resource availability | | |
| 3rd-5th | • Food resources<br>• Natural resources<br>• Source of fresh water<br>• Source of oxygen<br>• Recreation<br>• Water cycle | • Commerce<br>• Human population distribution<br>• Recreation<br>• Resources<br>• Transportation<br>• Weather impacts on humans | • Chemical pollution<br>• Human efforts to protect the ocean<br>• Human impacts on global climate change<br>• Legal efforts to protect the ocean<br>• Making informed decisions<br>• Marine debris<br>• Marine Protected Areas<br>• Marine reserves<br>• Marine sanctuaries<br>• Ocean resources are finite<br>• Overfishing | | |
| 6th-8th | • Biotic resources<br>• Food resources<br>• Process of photosynthesis<br>• Photosynthetic organisms<br>• Marine fisheries<br>• Sources of energy<br>• Source of fresh water<br>• Source of medicines<br>• Source of oxygen<br>• Source of salt | • Commerce<br>• Exploration<br>• Human cultures<br>• Human history<br>• Human population centers<br>• Human population distribution<br>• Recreation<br>• Transportation<br>• Weather impacts on humans | • Acid rain<br>• Acid deposition<br>• Aquaculture<br>• Bycatch<br>• Changing coastlines<br>• Changing ocean temperature<br>• Fisheries<br>• Greenhouse gases<br>• Human-made structures<br>• Introduced species<br>• Ocean acidification<br>• Overfishing<br>• Pollution<br>• Watersheds | • Distribution of energy (heat)<br>• Energy (heat) absorption | • Climate change<br>• Introduced species<br>• Influencing policy decisions<br>• Making informed decisions<br>• Marine Protected Areas<br>• Modifications to the landscape<br>• Pollution<br>• Reducing overfishing<br>• Reducing habitat destruction<br>• Sustainability |

| 6 | The ocean and humans are inextricably interconnected. | | | | |
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| | **Uses of the Ocean** | **Where People Live** | **Human Impact on the Ocean and Atmosphere** | **The Ocean Affects Weather and Climate which Impacts People** | **Responsibility and Advocacy for the Ocean** |
| 9th-12th | • Aquaculture<br>• Fisheries<br>• Food resources<br>• Human impacts on the ocean<br>• Non-renewable resources<br>• Renewable resources<br>• Sources of energy<br>• Source of fresh water<br>• Source of medicines<br>• Source of mineral ores<br>• Source of natural gas<br>• Source of oil<br>• Source of oxygen<br>• Source of salt | • Careers<br>• Climate<br>• Commerce<br>• Exploration<br>• Global economy<br>• Human cultures<br>• Recreation<br>• Transportation | • Algal blooms<br>• Biomagnification<br>• Burning fossil fuels<br>• Changing ocean temperature<br>• Effect of techno-logical advances<br>• Eutrophication<br>• Greenhouse gases<br>• Human effect on global climate change<br>• Impact on humans of natural hazards<br>• Human impact on ocean ecosystems<br>• Human impact on topography<br>• Human population growth<br>• Hydrofluorocarbon emissions<br>• Introduced species<br>• Ocean acidification<br>• Rising sea level | • Effect of changing weather and climate<br>• Effect of natural disasters<br>• Effective natural disaster warnings | • Education<br>• Legal efforts to protect the ocean<br>• Making informed decisions<br>• Marine Protected Areas<br>• Marine reserves<br>• Protecting marine resources<br>• Reducing biological and biogeochem-ical changes<br>• Reducing overfishing<br>• Reducing pollution<br>• Sustainability<br>• The ocean is finite |

| 7 | The ocean is largely unexplored. | | | |
|---|---|---|---|---|
| | **Life on Earth Depends on the Ocean** | **People Explore the Ocean** | **Ocean Exploration Requires Collaboration** | **Ocean Exploration Requires Technological Innovations** |
| K-2nd | • Requirements for life<br>• Scientific investigation | • Asking questions<br>• Ecosystem health<br>• Hobbies and careers<br>• Making observations<br>• Natural resources<br>• Tools and technology | | |
| 3rd-5th | | • Atmosphere<br>• Biosphere<br>• Ecosystem health<br>• Ecosystem interactions<br>• Lithosphere<br>• Natural resources<br>• Reasons for exploring<br>• Spirit of exploration | • Communication of information<br>• Engineering careers<br>• Making informed decisions<br>• Ocean hobbies<br>• Science careers<br>• Sustainability<br>• Technology | • Human immersion<br>• SCUBA<br>• Tools for exploration<br>• Tools for seeing underwater<br>• Tools for exploring ocean depths<br>• Tools for remotely collecting information<br>• Tools for surviving cold temperatures |

| 7 | The ocean is largely unexplored. | | | |
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| | Life on Earth Depends on the Ocean | People Explore the Ocean | Ocean Exploration Requires Collaboration | Ocean Exploration Requires Technological Innovations |
| 6th-8th | | • Advances in research and technology<br>• Climate research<br>• Collecting long-term data<br>• Discovering natural resources<br>• Discovering new habitats<br>• Discovering new species<br>• Human benefits from discovery<br>• Human impacts on the ocean<br>• Ocean geography | • Communication of information<br>• Community groups<br>• Environmental groups<br>• Governmental roles in ocean exploration<br>• Making informed decisions<br>• Role of youth in ocean exploration<br>• Science careers<br>• Sustainability | • Internet as a tool<br>• Ocean-observing systems<br>• Physical properties of the ocean<br>• Remote exploration<br>• Sonar<br>• Tools for exploration<br>• Tools for exploring under the water<br>• Tools for prolonged exploration |
| 9th-12th | | • Advances in research and technology<br>• Collecting long-term data<br>• Discovering new habitats<br>• Discovering new species<br>• Human benefits from discovery<br>• Human impacts on the ocean<br>• Sustainability of resources<br>• Use of resource | • Careers in ocean exploration<br>• Communication of information<br>• Global participation in ocean exploration<br>• Higher education in ocean exploration<br>• Making informed decisions<br>• Political engagement<br>• Science careers<br>• Sustainability<br>• Technology | • Computer technology<br>• Continuous data collection technology: sensors and transmitters<br>• Molecular analysis<br>• Ocean-observing systems<br>• Physical properties of the ocean<br>• Satellites<br>• Satellite image technology<br>• Scientific models<br>• Simulations<br>• Submersibles: HOV, ROV, AUV |

## Join us in Developing Supplements to Expand Ocean Literacy

There are two active efforts to develop supplements that will expand the scope of *Ocean Literacy: The Essential Principles of Ocean Sciences K-12*. The Traditional Knowledge Committee of the National Marine Educators Association is spearheading the development of a guide to Traditional Ecological Knowledge about the Ocean. If you are interested in joining this effort, please contact committee co-chairs Sylvia Spalding and Don Hudson at sylvia.spalding@noaa.gov or donhudson@chewonki.org.

COSEE Great Lakes is developing a Great Lakes supplement that will describe the essential principles and fundamental concepts necessary to understand this complex aquatic ecosystem in the center of the continent. Please contact Rosanne Fortner, Director, COSEE Great Lakes at fortner.2@osu.edu for additional information.